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The Ni-Cu-PGE-(Au-Te) potential of the Permo-Triassic boundary between Laurasia and Gondwana

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The long-lived geodynamic evolution of the Permo-Triassic boundary between Laurasia and Gondwana may have created the ideal conditions for the genesis of a trans-continental Ni-Cu-PGE-(Au-Te) mineralised belt in Europe. This working hypothesis stems from the recent understanding that orogenic processes play a fundamental role in the onset of chemical and physical triggers for the transport of metals from the metasomatised mantle through to various crustal levels. An insight into our renewed framework for the polyphased genetic evolution of magmatic sulfide mineral systems is provided by a series of mineralised occurrences in the Ivrea Zone of NW Italy, which formed at multiple stages over a > 80 Ma time interval. Between 290-250 Ma, a series of hydrated and carbonated ultramafic alkaline pipes containing Ni-Cu-PGE-(Te-Au) mineralisation was emplaced in the lower continental crust. At ~200 Ma, a subsequent mineralising event occurred in association with the emplacement of the La Balma-Monte Capio (LBMC) intrusion. Modelling of the LBMC parental magma shows derivation from ~30% partial melting of an anhydrous juvenile mantle at moderate pressure (< 7 GPa). The inferred composition of the parental melt is consistent with magmatism associated with the Central Atlantic Magmatic Province (CAMP). However, its tellurium-enriched composition together with the S-C-O isotope signature of the associated magmatic sulfide mineralisation cannot be reconciled with the CAMP source. It is argued that the geochemical and isotopic signature of the LBMC intrusion reflects interaction and mixing of a primitive magma sourced from a juvenile source with localised domains enriched in carbonate and metal-rich sulfides located in the lower crust, consistent with the composition of the Permo-Triassic pipes. Evidence of this magmatic interaction informs on the first-order processes that control enhanced metallogenic fertility along the margins of lithospheric blocks. The scenario depicted here is consistent with reactivation and enrichment of a Gondwana margin Ni-Cu-PGE-(Te-Au) mineral system during the breakup of Pangea. The lessons learnt in the Ivrea Zone natural laboratory may inform on the genesis of other Permo-Triassic magmatic mineral systems in continental Europe, such as the deposits in north-west Czech Republic and southern Spain, which display significant analogies with their counterparts in the Ivrea Zone. We suggest that these systems may have a common DNA related to a metallogenic belt forming at different stages during the complex evolution and multi-phase activation of the margin between Laurasia and Gondwana. The nature and localisation of the magmatic sulfide mineral systems along this belt indicate that enhanced potential for ore formation at lithospheric margins may be due not only to favourable architecture, but also to localised enhanced metal and volatile fertility.

Importantly, this hypothesis may explain why ore deposits along the margins of lithospheric blocks are not distributed homogeneously along their entire extension but generally form clusters. As mineral exploration is essentially a search space reduction exercise, this new understanding may prove to be important in predictive exploration targeting for new mineralised camps in Europe and elsewhere globally, as it provides a way to prioritise segments with enhanced fertility along extensive lithospheric block margins.